# Escherichia coli O157:H7 Outbreak Associated with Consumption of Ground Beef, June–July 2002

RICHARD L. VOGT, MD<sup>a</sup> LAURA DIPPOLD, MPH<sup>a</sup>

## **SYNOPSIS**

**Objective.** A case-control and environmental study tested the hypothesis that purchasing and eating ground beef from a specific source was the cause of a cluster of cases of hemolytic uremic syndrome (HUS) and *Escherichia coli* (*E. coli*) O157:H7 gastroenteritis.

**Methods.** A case-control study comparing risk factors was conducted over the telephone on nine case-patients with 23 selected controls. An environmental investigation was conducted that consisted of reviewing beef handling practices at a specific local supermarket and obtaining ground beef samples from the store and two households with case-patients.

**Results.** The analysis of the case-control study showed that eight case-patients (89%) purchased ground beef at Grocery Chain A compared with four controls who did not develop illness (17%) (matched odds ratio=undefined; 95% confidence interval 2.8,  $\infty$ ; p=0.006). The environmental investigation showed that Grocery Chain A received meat from Meatpacker A. Laboratory analysis of meat samples from Meatpacker A and Grocery Chain A and stool samples from some patients recovered an identical strain of *E. coli* O157:H7 according to pulse-field gel electrophoresis.

**Conclusions.** Both the case-control and environmental studies showed that purchasing ground beef at Grocery Chain A, which received ground beef from Meatpacker A, was the major risk factor for illness in eight case-patients; the ninth casepatient was found to be unrelated to the outbreak. Furthermore, meat from Meatpacker A was associated with a nationwide outbreak of *E. coli* O157:H7 illness that resulted in the second largest recall of beef in U.S. history at the time.

Address correspondence to: Richard L. Vogt, MD, Tri-County Health Department, 7000 East Belleview, Ste 301, Greenwood Village, CO, 80111; tel. 303-846-6203; fax 303-220-9208; e-mail <a href="mailto:rvogt@tchd.org">rvogt@tchd.org</a>.

©2005 Association of Schools of Public Health

<sup>&</sup>lt;sup>a</sup>Tri-County Health Department, Greenwood Village, CO

Escherichia coli (E.coli) O157:H7 was identified as an agent that caused gastrointestinal illness in 1982. Riley et al. reported two outbreaks in Oregon and Michigan that affected 47 individuals and were caused by the consumption of contaminated beef patties.1 They attributed the outbreaks to a rare, newly identified strain of E. coli. After this first report, several subsequent outbreaks of E. coli O157:H7 were linked to the consumption of contaminated beef, other foods, water, and contact with animal reservoirs, as well as person-toperson transmission.<sup>2</sup> Foods of bovine origin, particularly ground beef, are common causes of sporadic infections and outbreaks of E. coli O157:H7.3,4 Surveys conducted on feedlots demonstrate that cattle can be infected symptomatically with E. coli O1575 and that E. coli O157 can routinely be identified in feces in these feedlots.6

E. coli O157:H7 in humans often causes bloody diarrhea and abdominal cramps with little or no fever; the diarrheal illness usually resolves in seven to 10 days. The infection can also cause a complication called hemolytic uremic syndrome (HUS), hemolysis, thrombocytopenia, renal failure, and occasionally death. HUS develops in as many as 10% of patients with symptomatic E. coli O157:H7 infection, and predominantly affects children younger than 10 years of age. Treatment of HUS includes dialysis and transfusions of red blood cells and/or platelets.2

Infections with E. coli O157:H7 and HUS are notifiable conditions in the state of Colorado.<sup>7</sup> Physicians and laboratories are required to report cases of illness to the Colorado Department of Public Health and Environment (CDPHE) or their local health department. Information on case reports is entered into a computerized database called the Colorado Electronic Disease Reporting System (CEDRS).

In June-July 2002, a total of nine patients with HUS and/or E. coli O157:H7 infections was recorded in CEDRS in the Tri-County Health Department (TCHD) area that consists of Adams, Arapahoe, and Douglas Counties, Colorado. In comparison, the TCHD had a median of one report of HUS or E. coli O157:H7 infection in each two-month period in 2001. Concurrently, ground beef from Meatpacker A was found to be positive for E. coli O157:H7 through a United States Department of Agriculture (USDA) routine sampling and testing program. This initiated a product recall that was independent of the investigation of E. coli O157:H7 infections in humans. From June through July 2002, the TCHD investigated this cluster of nine patients (two with HUS, six with gastroenteritis, and one with both). Initially, interviews of the nine patients were completed using a standard questionnaire developed by the CDPHE for reporting E. coli O157:H7 and HUS; the survey includes questions about the patients' basic demographics, illness history, and potential risk factors for illness. A hypothesis linking beef consumption from a local supermarket emerged, and an epidemiologic case-control and an environmental study were undertaken to better determine the exact risk factors for infection.

## **METHODS**

A case-control study was initiated by the TCHD to determine risk factors for illness among case-patients. For this study, a case was defined as a confirmed diagnosis of E. coli O157:H7

and/or HUS reported to the TCHD with symptom onset from June 14, 2002, through July 14, 2002. Three controls were selected for each of the nine TCHD cases. Controls were selected by taking the telephone numbers of the casepatients and progressively dialing one digit higher than each phone number until three controls per case were interviewed. When a group of business phone numbers was encountered, a total of 10 digits were skipped. Controls were age-matched to case-patients in pediatric and adult categories based on groupings of younger than or older than 18 years of age. One control was chosen per household; among households with two or more individuals identified as potential controls, the interviewer randomly selected the control using a standard method. A parent or guardian of the child was queried when the case-patient or control was younger than 18 years of age. Case-patients and controls were asked basic demographic, symptom, and potential risk factor information. Those interviewed were also asked about the following: (1) consumption of ground beef, (2) travel history, (3) specific water exposure, (4) specific animal exposure, (5) restaurant exposure, (6) consumption of previously identified high-risk foods, and (7) grocery stores where they shopped in the month prior to illness.

The responses of case-patients and controls were recorded on the questionnaire that had pre-selected categories of responses. Interviewers were instructed to read only the questions on the questionnaire. If respondents had difficulty volunteering information, they were provided a list of possible responses that were listed on the questionnaire. Potential risk factors were determined by exposure frequencies.8 Matched odds ratios (ORs) with 95% confidence limits (CLs) were calculated using StatXact with Cytel Studio computer software.9

An environmental investigation was conducted to accompany the epidemiologic investigation. The TCHD obtained frozen ground beef product from the freezers of two ill patients and initially submitted them to the CDPHE laboratory for testing. The TCHD environmental health staff also interviewed and obtained ground beef grinding logs from Grocery Chain A stores where ill patients stated in the preliminary questionnaire that they had purchased ground beef. An independent environmental investigation conducted by the USDA collected several samples of meat from the plant of Meatpacker A.

Pulse-field gel electrophoresis (PFGE) has been shown to be helpful in identifying strain specific laboratory characteristics of E. coli O157:H7.10,11 The CDPHE used PFGE to analyze environmental and human isolates of E. coli O157:H7; then the isolates were sent to the Centers for Disease Control and Prevention (CDC) in Atlanta for confirmation, using PFGE analysis to determine if the environmental and human strains were similar.

### **RESULTS**

The case-control study sample consisted of 32 subjects (nine cases and 23 controls). A total of 748 phone calls were made to identify the 23 controls. Of the failures, a total of 288 phone numbers did not have a response; 231 were businesses or fax numbers; 125 were disconnected; 60 had household members who did not meet our criteria; and 17 refused

an interview. Four additional acceptable controls were excluded from analysis due to reported illness in the previous month.

Analysis showed that eight case-patients (89%) purchased ground beef at Grocery Chain A compared with four controls who did not develop illness (17%) (matched OR= undefined; 95% confidence interval (CI) 2.8,  $\infty$ ; p=0.006). General-purpose grocery shopping at Grocery Chain A, however, was not a significant risk factor for illness (matched OR=5.3; 95% CI 0.5, 285.7; p=0.18). Consuming ground beef of any form in the past month was not associated with illness, but all of the case-patients reported eating ground beef compared with 19 controls (83%). Previously identified high risk foods, such as unpasteurized milk or juices, were not associated with illness and were not consumed by case-patients. Seven case-patients (78%) reported a preference for eating well-done beef.

The environmental investigation identified that Grocery Chain A stores, where eight of nine case-patients stated they had purchased ground beef, had received ground beef products from several different suppliers. The grocery chain reground them on-site in refrigerated rooms and then repackaged them with Grocery Chain A's name on the package. Grinders were washed, rinsed, and sanitized with quaternary ammonia once a day in the evening. Logs of ground beef grinding revealed that Grocery Chain A stores reground meat from Meatpacker A that had a production date of May 31, 2002. This finding correlated with a nationwide recall of 354,200 pounds of ground beef products produced on May 31, 2002, by Meatpacker A because of the detection of E. coli 0157:H7 during routine microbiologic testing at the plant.<sup>12</sup> Because grinders of Grocery Chain A were washed, rinsed, and sanitized only once a day, potential cross-contamination of non-Meatpacker A ground beef could not be ruled out.

Of the nine TCHD case-patients, seven were culture-con-

firmed E. coli O157:H7. PFGE analysis conducted by the CDPHE and the CDC using two restriction enzymes indicated that six of the seven human isolates of E. coli O157:H7 from the TCHD case-patients were identical to E. coli O157:H7 isolates recovered in beef from Meatpacker A and from ground beef that was purchased from Grocery Chain A obtained from the two TCHD patients' homes. 12 The seventh culture-confirmed case-patient was an adult who had a different PFGE pattern, had not eaten or purchased ground beef at Grocery Chain A, and therefore was not part of the outbreak. One culture-confirmed case-patient linked to the outbreak had HUS. Two TCHD case-patients who had only HUS had epidemiologic links to the outbreak: one was linked to a sibling who matched the outbreak PFGE pattern, and one was linked to a ground beef sample obtained in the home that matched the outbreak PFGE pattern.

Illness onsets of the case-patients (n=9) occurred from June 14 through July 7 (see Figure), and the median age of outbreak case-patients was 14 years old (range = 2–47 years old). The case-patient not linked to the outbreak was the only adult in the group. Five were male, and four were female. Case-patients had the following symptoms: eight (89%) had diarrhea; seven (78%) had bloody diarrhea; six (67%) had abdominal cramps; five (56%) had vomiting; four (44%) had fever; three (33%) had HUS; and one (11%) had chills.

Of the case-patients, only one 16-year-old patient with HUS received antibiotics. This patient received trimethoprim-sulfamethoxazole during a visit to a medical center. Several days later, the patient received levofloxacin during the initial two-day hospitalization. No antibiotics were given after transfer to a second hospital where dialysis was performed. The three case-patients with HUS were the only patients who were hospitalized. They were all dialyzed and transfused during their hospitalization.

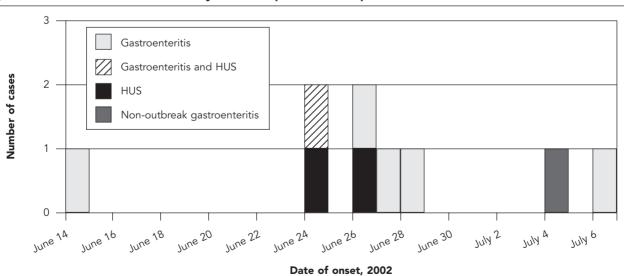


Figure. Onset of illnesses for Tri-County Health Department case-patients of E. coli O157:H7

HUS = hemolytic uremic syndrome

#### **DISCUSSION**

This outbreak investigation conducted by the TCHD was helpful in confirming other state and national findings that contaminated meat from Meatpacker A was the source of an outbreak of *E. coli* O157:H7. The case-control study and environmental investigation results presented in this paper were shared throughout the investigation with state and national investigators as a matter of course. Eventually, a total of 22 Colorado patients with *E. coli* O157:H7 infection and/or HUS were traced back to ground meat from Meatpacker A. Because some contaminated meat was shipped outside Colorado, other states also reported human illnesses linked to this product. <sup>12</sup>

The following evidence supports the association of consumption of contaminated beef produced by Meatpacker A with illness due to  $E.\ coli\ O157:H7$  infection: (1) results of a case-control study showed that those who purchased ground beef at Grocery Chain A stores were at increased risk of becoming ill; (2) a trace-back of the leftover ground beef indicated that it was reground at Grocery Chain A using recalled meat from Meatpacker A; (3) analysis recovered  $E.\ coli\ O157:H7$  from leftover ground beef from two of the patients' homes; and (4) PFGE results demonstrated a unique strain of  $E.\ coli\ O157:H7$  in human isolates, leftover meat, and meat recalled from Meatpacker A.

The case-control study did not identify either the general consumption of ground beef or eating rare beef as risk factors for illness. This is probably because both case-patients and controls in the epidemiologic study were asked about consumption of beef within the past month and that ground beef was consumed by most non-vegetarian controls at some time during this monthly period. It can be conjectured that inadequate handwashing or inadequate kitchen utensil washing that caused cross-contamination of other food items could have occurred. Alternatively, fully cooking ground beef may not have completely killed bacterial pathogens due to heavy beef contamination with *E. coli* O157:H7. However, quantitative determinations of *E. coli* O157:H7 in beef were not done in this outbreak.

Subsequent to the detection of this outbreak, the nation-wide recall was expanded on July 19, 2002, to a recall of 18.6 million pounds of fresh and frozen ground beef and beef trimmings, the second largest recall in U.S. history. This expanded recall was a result of the identification of human cases linked to this product and additional beef samples found to be positive for *E. coli* O157:H7. The extent to which the recalled meat was repackaged and distributed under other labels is unclear, potentially making it difficult to identify the affected lots by simple inspection of the package. Grocery Chain A also conducted a ground beef recall since it reground and repackaged meat from Meatpacker A.

In this outbreak, the USDA testing identified *E. coli* contamination concurrently with the identification of human cases of illness. While this is a partial success, it is important to identify environmental hazards in advance of the development of human disease to be truly effective. Further considerations for preventing the distribution of beef from a meatpacker while awaiting microbiologic laboratory analyses may be an important lesson learned from this outbreak.

Since the first published report of illness with E. coli

O157:H7 about two decades ago, illnesses caused by contaminated beef continue. Public health prevention measures include the following: (1) reviewing and developing procedures that will reduce the risk of fecal contamination at meatpacking plants; (2) storing ground beef products at temperatures less than 40 degrees Fahrenheit; (3) using a thermometer to check the temperature of cooked beef to make sure that it exceeds 160 degrees Fahrenheit in order to kill pathogenic bacteria; (4) washing and sanitizing preparation surfaces and utensils after preparing raw meats; and (5) washing hands after handling raw meats. After this outbreak, the USDA publicly stated that it was going to better identify unsafe conditions at the meatpacking plants it currently inspects. It will remain to be seen whether these enhanced activities will reduce the incidence of foodborne illness caused by contaminated meat.

Finally, researchers have shown that *E. coli* O157:H7 can be eliminated by treatment with irradiation.<sup>13</sup> The USDA has issued regulations on the irradiation of beef products to eliminate microbiologic agents.<sup>14</sup> However, because of consumer resistance, this practice to eliminate harmful pathogens has yet to become commonplace.

Ground beef contaminated with *E. coli* O157:H7 continues to be a source of severe illness, including HUS. It is important for the industry and its regulators to re-examine and revise current practices and regulatory functions to provide a safer product to the general public.

The authors would like to acknowledge Jenna Patnaik of the Tri-County Health Department for her statistical and epidemiologic assistance. Thanks to Paula Allderdice, Gary Hartzell, Donna Hite-Bynum, Meredith Hatterman, Marilyn Swett, Stacy Weinberg, Bruce Wilson, and Candy Wingrove of Tri-County Health Department; Ken Gershman, MD, Karen Gieseker, MD, James Beebe, PhD, Ann Woo-Ming, Nicole Haubert, and Pam Shillam of the Colorado Department of Public Health and Environment; and Allen Hightower, Mary Ann Fair, and Kristy Kubota at the Centers for Disease Control and Prevention for their epidemiologic, statistical, environmental, and laboratory assistance with this outbreak investigation.

#### REFERENCES

- Riley LW, Remis RS, Helgerson SD, McGee HB, Wells JG, Davis BR, et al. Hemorrhagic colitis associated with a rare *Escherichia coli* serotype. N Engl J Med 1983;308:681-5.
- Tarr PI. Escherichia coli O157:H7: clinical, diagnostic, and epidemiological aspects of human infection. Clin Infect Dis 1995;20:1-10.
- Cieslak PR, Noble SJ, Maxson DJ, Empey LC, Ravenholt O, Legarza G, et al. Hamburger-associated *Escherichia coli* O157:H7 infection in Las Vegas: a hidden epidemic. Am J Public Health 1997; 87:176-80.
- Tuttle J, Gomez T, Doyle MP, Wells JG, Zhao T, Tauxe RV, Griffin PM. Lessons from a large outbreak of *Escherichia coli* O157:H7 infections: insights into the infectious dose and method of widespread contamination of hamburger patties. Epidemiol Infect 1999;122:185-92.
- Gannon VP, Graham TA, King R, Michel P, Read S, Ziebell K, Johnson RP. Escherichia coli O157:H7 infection in cows and calves in a beef cattle herd in Alberta, Canada. Epidemiol Infect 2002; 199-163-79
- Galland JC, Hyatt DR, Crupper SS, Acheson DW. Prevalence, antibiotic susceptibility, and diversity of *Escherichia coli* O157:H7 isolates from a longitudinal study of beef cattle feedlots. Appl Environ Microbiol 2001;67:1619-27.
- Named reporting of certain diseases and conditions. Colorado Revised Statutes. Title 25, Article 1, Section 122 (2002).

- 8. Centers for Disease Control and Prevention. Epi Info 2000: Version 1.1.2. Atlanta: CDC; 2001.
- 9. Cytel Statistical Software. StatXact with Cytel Studio: Version 6.0. Cambridge, MA: Cytel Software Corp.; 2003.
- Meng J, Zhao S, Zhao T, Doyle MP. Molecular characterisation of *Escherichia coli* O157:H7 isolates by pulsed-field gel electrophoresis and plasmid DNA analysis. I Med Microbiol 1995:42:258-63.
- and plasmid DNA analysis. J Med Microbiol 1995;42:258-63.

  11. Johnson JM, Weagant SD, Jinneman KC, Bryant JL. Use of pulsed-field gel electrophoresis for epidemiological study of Escherichia coli O157:H7 during a food-borne outbreak. Appl Environ Microbiol 1995;61:2806-8.
- Multistate outbreak of Escherichia coli O157:H7 infections associated with eating ground beef—United States, June–July 2002. MMWR Morb Mortal Wkly Rep 2002;51:637-9.
- Thayer DW, Boyd G. Elimination of Escherichia coli O157:H7 in meats by gamma irradiation. Appl Environ Microbiol 1993;59: 1030-4.
- Food and Drug Administration, Department of Health and Human Services (US). 21 C.F.R. part 179 final rule: irradiation in the production, processing and handling of food. Fed Register 1990; 55:18538-18544.